Solutions to EM Spectrum Questions and Problems:

Questions:

1. *If all objects radiate energy as electromagnetic radiation, why can’t we see objects in a darkened room?*

All objects radiate infrared radiation, which is a longer wavelength than our eyes are sensitive to. An infrared camera, infrared binoculars, or other such device would show this radiation.

1. *Are the wavelengths of radio waves longer or shorter than those detectable by your eyes*?

Radio waves have much longer wavelengths, and thus much lower frequencies than visible light. Our eyes do not detect radio waves.

1. *Can we see radio waves? Can we hear radio waves? Why or Why not?*

We cannot see radio waves since they are at a wavelength our eyes do not detect. We cannot hear radio waves until they are converted to sound waves. Sound waves are a mechanical wave which requires a medium to travel through, i.e., air. They travel at a much slower speed than electromagnetic waves. The radio waves are received by the radio and converted to a current which drives a speaker. The speaker produces the sound waves we hear.

1. *Do radio waves or sound waves travel faster? Explain your answer.*

As explained above, radio waves travel faster since they are electromagnetic waves which all travel at the speed of light, 3 x 108 m/s. Sound waves travel much slower, about 343 m/s in room temperature air. Sound requires the vibration of matter to carry the energy of the wave, EM waves can propagate through the vacuum of space.

1. *Is space empty or full of electromagnetic waves? Give an explanation.*

Space is full of electromagnetic waves, from radio through gamma rays. EM waves do not require a medium to travel, hence they can move through the vacuum of space.

1. *Suppose a light wave and a sound wave have the same frequency. Which has the longer wavelength?*

Using the equation: λ = c/f for the light wave, where c = 3 x 10 8 m/s, and using λ = v/f for the sound wave, where v = 343 m/s.   
A typical frequency of light is 8 x 1014 Hz. This would give a light wavelength of 6.85 x 10-11 meters, and a sound wavelength of 7.8 x 10-13 meters. So the light wave is longer.

Problem Solutions:

1. *Electromagnetic radiation has been detected with a frequency as low as 0.01 Hz. What is the wavelength of such a wave? (show work)*

From c = λf, we write: λ = c/f, where c = 3 x 108 m/s, and f =0 .01 Hz

Then: λ = (3 x 108)/0.01  
 λ = 3 x 1010 meters  
 This is more than 1 billion meters – a wavelength one fifth the distance to the sun!

1. *Radiation emitted in outer space by hydrogen atoms have a wavelength of 21 centimeters. What is the frequency of this radiation? (show work)*

From c = λf, we write: f = c/λ, where c = 3 x 108 m/s, and λ =21 cm = 0.21 m.  
Then: f = (3 x 108)/0.21 = 1.4 x 109Hz  
This radiation is in the microwave part of the spectrum.

1. *Using the table for metric prefixes below, and using the electromagnetic spectrum wavelengths, determine what part of the spectrum each of the following wavelengths belong to:*
2. *2.6 µm, b.) 34 m, c.) 0.54 nm, d.) 0.0032 nm, e.) 0.620 µm, f.) 310 nm*

Using a spectrum chart that has all meters for wavelengths requires each of the above to be in the proper units:

1. 2.6 µm = 2.6 x 10-6 m. This is in the near infrared (close to visible light) part of the spectrum.
2. 34 m is in the radio part of the spectrum (between FM and AM radio waves)
3. 0.54 nm = 0.54 x 10-9 m. This is far ultraviolet, near x-ray wavelength.
4. 0.0032 nm = 3.2 x 10-12 m. This is in the gamma ray part of the spectrum.
5. 0.620 µm = 0.620 x 10-6m. This is in the infrared part of the spectrum.
6. 310 nm = 310 x 10-9m. This is on the border of UV and X-rays.